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EFFECTS OF DIURON ON WEAR OF SPRAY NOZZLES[1/]

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The herbicide diuron [3-(3,dichlorophenyl)-1, 1-dimethylurea] has come into wide usage in the rain-grown portions of the Cotton Belt. It is now widely used both as preemergence and postemergence sprays. The herbicide is used as a liquid suspension and as wettable powder.[3/]

The introduction of diuron, with a surfactant, as a postemergence treatment has increased the use of the cheaper wettable powder formulation. Wettable powders, however, present two significant practical problems--adequate agitation of solutions, and increased wear of sprayer parts (Fig. 1).

Metering of spray depends on viscosity and physical properties of formulation, pressure, and orifice size. Wear on nozzle tips can seriously affect the rate of herbicide deposited per acre. Increasing the rate per acre adds extra cost and increases the risk of crop injury and chemical residue in the soil, particularly when broadcast applications are used.

Brass nozzle tips have been used extensively for the application of diuron. Research in other locations[4/] has shown rapid wear rates with brass spray orifices. Harder orifices are available in stainless steel, hardened stainless steel, and chrome-plated brass.

The tests described herein were designed to provide information for farm use.

1/ Cooperative investigations between Agricultural Engineering Research Division and the Crops Research Division, ARS, USDA, and the Delta Branch, Agricultural Experiment Station, Stoneville, Mississippi. The work is a contribution to Regional Cotton Mechanization Project S-2.

2/ Agricultural Engineers, Agricultural Engineering Research Division, ARS, and Agronomist, Crops Research Division, ARS, respectively.

3/ The authors wish to acknowledge the cooperation of the E. I. du Pont de Nemours & Co., Wilmington, Del., who supplied experimental samples of diuron formulated as a wettable powder (Darmex DW) and as a liquid (Karmex DL). Mention of a producing firm and products does not constitute their endorsement by the U.S. Department of Agriculture over other firms and their similar products.

4/ Boyce, E. K. The Effect of Wettable Powder Herbicides on Sprayer Nozzle Tips. Association of Southern Agricultural Workers, Inc. 60th Annual Convention Proceedings, pp. 49-50. 1963 (abstract)

Figure 1. Case and rollers from pump worn past repair by abrasive action of a wettable powder.

TEST EQUIPMENT

Figure 2 shows the self-contained spray unit used in these tests. Six nozzles could be mounted in the removable top. The spray pump was driven by an electric motor. Two gages were used in conjunction with the pressure regulator. Hydraulic agitation was employed to maintain uniform spray mixtures. The tank and spraying system was covered to prevent dust from entering the spray mixture and giving erroneous results.

An electrically operated automatic device for determining volume flow from spray tips is shown in figure 3. Accurately timed amounts were caught in the graduate shown under the spray nozzle.

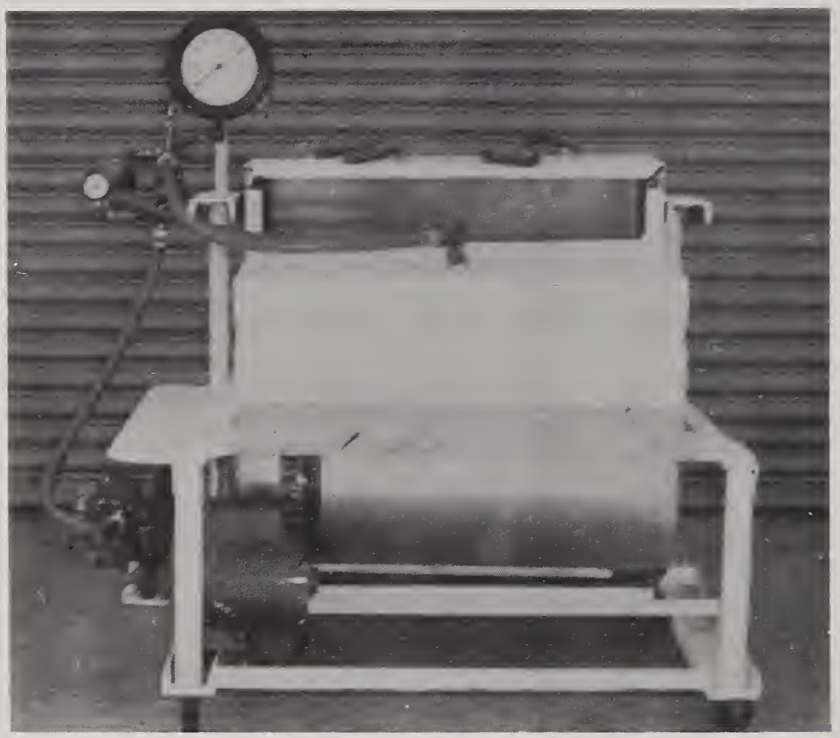
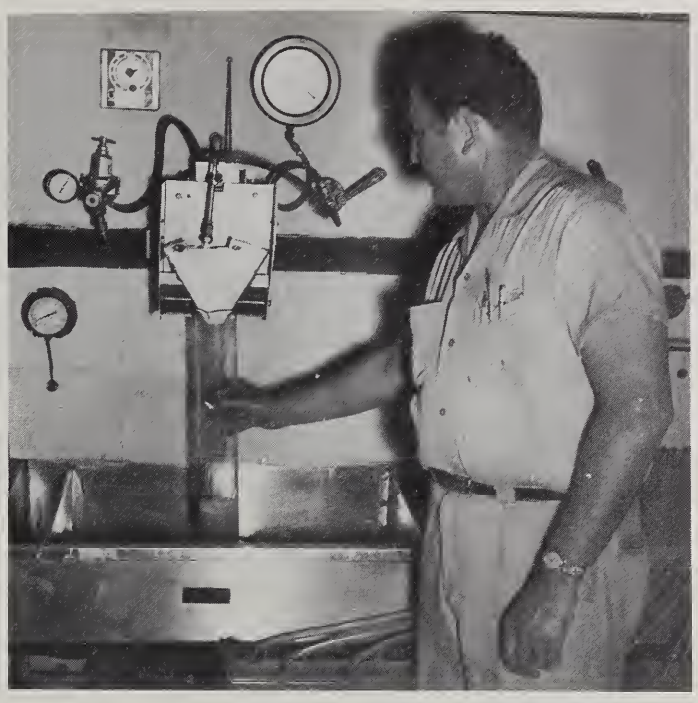


Figure 2. Self-contained spray system for wear tests. Six nozzles are mounted in removable top. System has electrically driven pump, hydraulic agitation, and accurate pressure regulation.

Figure 3. Calibration device for accurate flow measurement of spray nozzles. Timer connected to an air cylinder moves nozzle over graduate and then moves nozzle away after desired interval.



The controlled-speed conveyor shown in figure 4 was constructed for spray pattern determination. Strips of filter paper, premarked in 1-inch segments, were passed under the spray nozzle on a miniature cart and sprayed with a mixture containing a fluorescent dye. Quantitative measurements were then made with a fluorometer.

Figure 4. Conveyor for spray pattern determination. Variable speed motor drives twin belts that take cart under spray nozzle. Filter paper strip is taped across cart to receive the dye mixture. Paint pressure pot contains spray mixture.

TEST PROCEDURES

The overall study of nozzle wear consisted of three laboratory tests:

1. A comparison of the abrasiveness of diuron formulated as a wettable powder (DW) with diuron formulated as a liquid suspension (DL).
2. A comparison of the wear resistance of brass, stainless steel, and chrome-plated brass nozzle tips.
3. A study of the expected increase in cost of herbicide per acre due to wear of brass nozzles.

Spraying pressure was conducted at 30 p.s.i.g. (pounds per square inch gage) in all tests. All rates of diuron refer to active ingredient.

Comparative Abrasiveness of DL and DW

A mixture of 2 pounds of diuron (DW) in 40 gallons of water was sprayed through six brass nozzle tips. The tips had a rated delivery of 0.4 g.p.m. (gallon per minute) at 40 p.s.i.g. with an 80° spray angle. The test treatment was concluded after 30 hours. During the test period the six nozzles were recalibrated after the first and third hour and every 3 hours thereafter. The tank was drained after each 3 hours of recirculating and was refilled with a fresh mixture.

Frequent changing of the diuron mixture was theoretically necessary to prevent the particles from "wearing smooth" because of continuous recirculation. It was possible that the abrasiveness of the herbicide material would decrease over a long period of recirculation.

The entire procedure was repeated with treatments of 2 pounds of diuron (DL) in 40 gallons of water and with 40 gallons of water alone.

The spray pattern of the six brass nozzles was checked at the beginning and at the end of the diuron (DW) treatment (extended to 50 hours) to determine if the wear of the nozzles affected the spray distribution across the swath. This information was obtained by passing strips of filter paper underneath the swath. The strips were cut into 1-inch segments and each segment then eluted in 10 ml. (milliliter) of alcohol. (The material sprayed through the nozzles was a fixed mixture of water and Rhodamine B, a fluorescent dye.) The degree of fluorescence of a sample of the alcohol-dye solution was then determined as described previously.[5] Higher fluorometer readings were related linearly to higher concentrations of spray material.

5/ Wooten, O. B., and Holstun, J. T., Jr. Development of a Multi-Purpose Postemergence Applicator for Cotton. Association of Southern Agricultural Workers, Inc. 60th Annual Convention Proceedings, p. 50. 1963 (Abstract.)

Wear Resistance of Brass, Stainless Steel, and Chrome-Plated Brass Nozzles

A mixture of 1.6 pounds of diuron (DW) and 1 pint of surfactant material in 25 gallons of water was recirculated at 30 p.s.i.g. through six unused nozzle tips of brass, stainless steel, and chrome-plated brass. Each tip had a rated delivery of 0.2 g.p.m. at 40 p.s.i.g. with an 80° spray angle. The procedure of changing the material and recalibrating the nozzles remained the same as for the DL-DW abrasiveness test. However, only 18 hours of running was necessary to establish definite differences in the wear of brass, stainless steel, and chrome-plated brass nozzles.

The 1.6 pounds of diuron plus 1 pint of surfactant in 25 gallons of water was selected as the maximum concentrate likely to be applied in the field.

Cost of Herbicide Per Acre Related to Nozzle Wear

Nozzles spaced 10 inches apart and rated to deliver 0.2 g.p.m. at 40 p.s.i.g. would spray 25 gallons of material per acre at 30 p.s.i.g. if carried at a speed of 4 m.p.h. Therefore, spraying for 30 hours in the laboratory was equivalent to covering 195 acres in the field with 4-row equipment.

Costs were figured on a basis of $2.95 per pound of 80 percent active diuron and $1 per pint of surfactant. Therefore, the initial cost of material when applying 0.8 pound active diuron (DW) and 1 pint of surfactant would be $3.95 per acre. The increase in rate of application caused by wear of nozzles was converted to an increase in cost of material.

The procedure of regularly recalibrating the nozzles and changing the herbicide mixture in the tank every 3 hours remained the same as for the two previously described tests.

RESULTS AND DISCUSSION

Comparative Abrasiveness of DL and DW

The wear of 80° fan-type brass nozzle tips with rated discharge of 0.4 g.p.m. at 40 p.s.i.g. is graphically shown in figure 5 when the mixtures of diuron (DL), diuron (DW), and water alone were sprayed through the brass nozzles for 30 hours. The degree of nozzle wear is presented as an increase in flow through the nozzle over the initial flow at the same pressure (30 p.s.i.g.). As the graph shows, the DW material was slightly more abrasive to brass than the DL material. Water alone caused approximately a four percent increase in nozzle flow after 30 hours of spraying.

The highest rate of flow increase for all mixtures occurred during the first hour of spraying. This may have been due to relatively rapid wear of burrs or rough edges in the nozzle which were left from drilling the orifice in the manufacturing process.

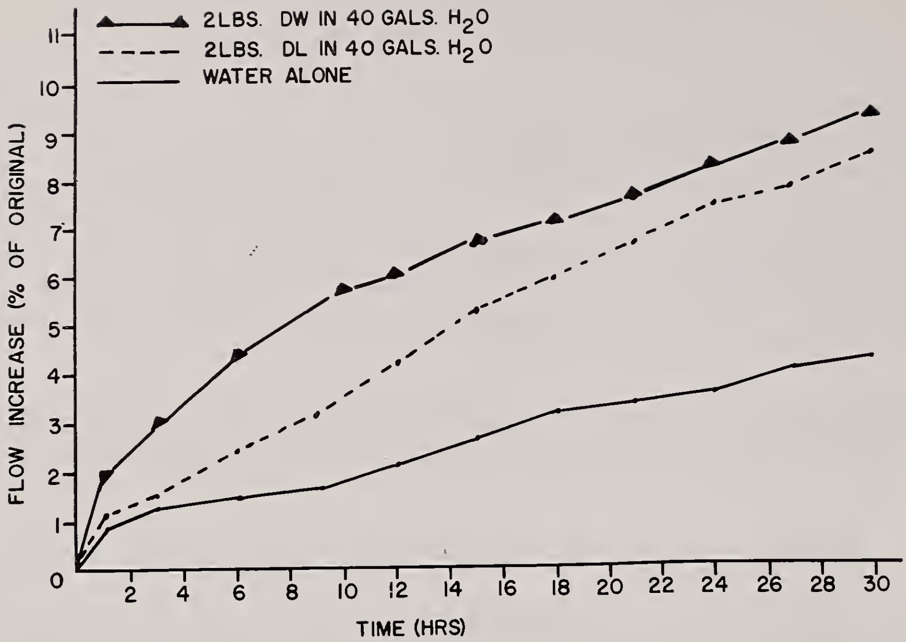


Figure 5. Abrasiveness of diuron (DW), diuron (DL), and water to brass nozzles with rated discharge of 0.4 g.p.m. at 40 p.s.i.g. when sprayed through the nozzles at 30 p.s.i.g. for 30 hours.

The DW treatment was extended to 50 hours of spraying for purposes of making a more reliable determination of the wear effects on the spray pattern of the nozzles. Figure 6 shows the average wear effects on the spray pattern of the six nozzles before and after spraying for 50 hours.

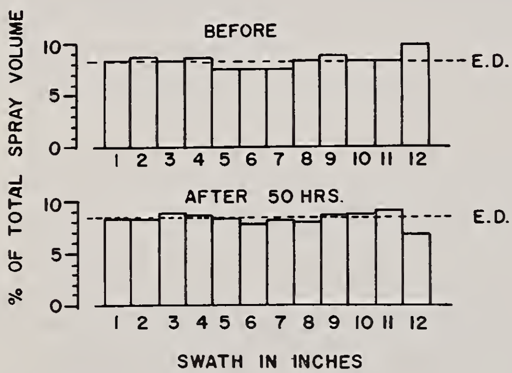


Figure 6. Average spray distribution of six brass nozzles before and after spraying at 30 p.s.i.g. a mixture of 2 pounds of diuron and 40 gallons of water for 50 hours. E. D. equals even distribution.

Even distribution across the 12-inch band would be 100 percent of the total volume sprayed divided by 12 inches, or 8.33 percent of the total volume per inch. Ideal, or even, distribution is represented in figure 6 by the dotted line across the graph. The spray pattern of the nozzles was not seriously affected by the wear. The spray distribution was about as near to being even after 50 hours of spraying as it was before the nozzles were used.

As expected, brass nozzles were much more susceptible to wear than either stainless steel or chrome-plated brass nozzles. The flow increase through

the brass nozzles was approximately 19 percent after only 18 hours of spraying, whereas that of the stainless steel was only about 4 percent (Fig. 7). Wear of the chrome-plated brass nozzle was negligible after the first hour of spraying.

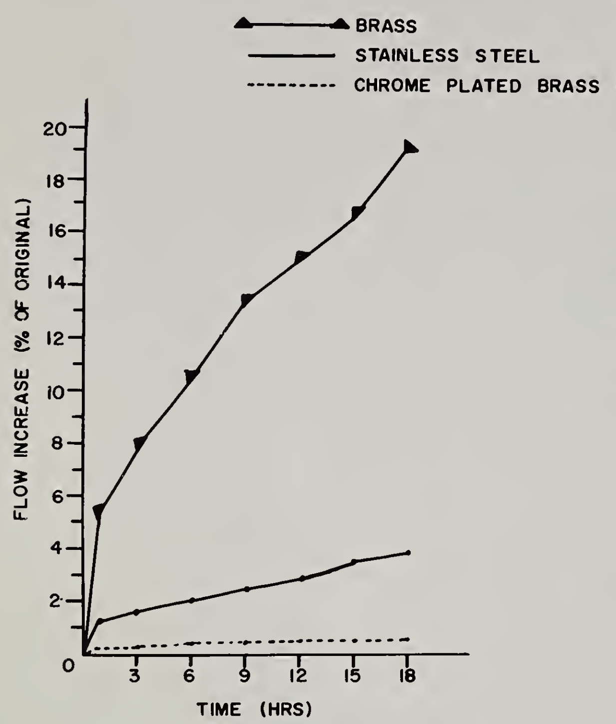


Figure 7. Progressive wear of brass, stainless steel, and chrome-plated brass nozzles after spraying at 30 p.s.i.g. a concentrate of 1.6 pounds of diuron DW and 1 pint of surfactant in 25 gallons of water. All of these nozzles initially had a rated discharge of 0.2 g.p.m. at 40 p.s.i.g.

The particular nozzle size for this test was 0.2 g.p.m. (rated at 40 p.s.i.g.), while the size of nozzle used for the DW-DL abrasiveness test was 0.4 g.p.m. A general comparison of the relative wear resistance of the two sizes of nozzles may be made by comparing the DW curve in figure 5 with the similar curve for brass tips in figure 7. Although the concentrations of DW per gallon of water were similar, the percent increase of flow through the smaller nozzle was over twice that of the percent increase through the larger nozzle after 18 hours of spraying. Certainly, the smaller nozzle may be classified as "worn out" after 18 hours of spraying.

Cost of Herbicide Per Acre As Related to Nozzle Wear

If no adjustment is made to allow for the wear of brass nozzles, one may expect a corresponding increase in the rate of herbicide applied per acre. Figure 8 illustrates how nozzle wear would affect herbicide cost per acre when nozzles rated at 0.2 g.p.m. (40 p.s.i.g.) are

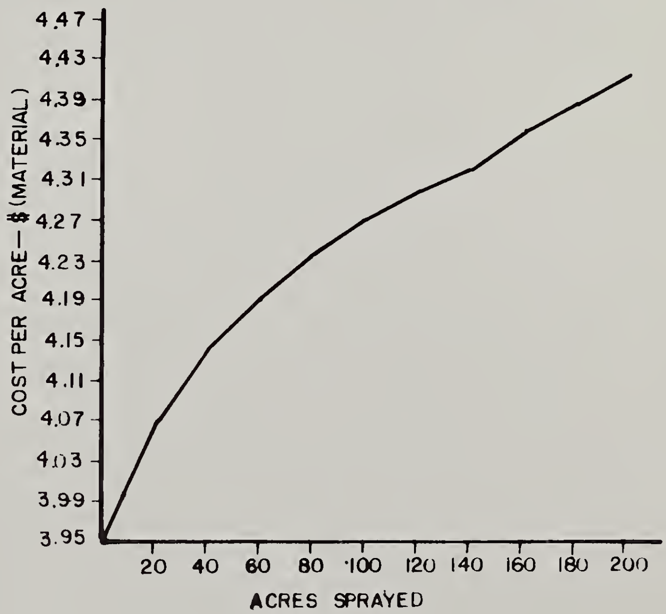


Figure 8. The effect of nozzle wear on the cost of herbicide per acre when 4 brass nozzles (rated at 0.2 g.p.m. at 40 p.s.i.g. with 80° fan spray) per row are used to spray a concentrate of 0.8 pound of diuron DW and 1 pint of surfactant in 25 gallons of water with a 4-row applicator traveling 4 m.p.h.

used to apply a mixture of 0.8 pound of diuron and 1 pint of surfactant in 25 gallons of water per acre as a lay-by spray. With 4-row equipment, the increase in cost of herbicide due to increased flow through worn nozzles after spraying 200 acres would amount to approximately $0.45 per acre over the initial cost of $3.95 per acre.

The progressive increase in flow through constantly wearing nozzles may be offset by decreasing the operating pressure on the nozzles. To insure a relative constant rate of application in the field, brass nozzles should be recalibrated as often as once a day and pressure adjusted accordingly.

It is suggested that careful consideration be given to the wear resistance of stainless steel, hardened stainless steel, and chrome-plated brass nozzles. Although these nozzles cost more initially than brass nozzles, their use may be justified because of their longer life and the greatly decreased need for continuous recalibration. Nozzle tips of the various materials are priced in the increasing order of brass ($0.50), stainless steel ($1.50), hardened stainless steel ($1.95), and chrome-plated brass ($3.50). Hardened stainless steel is known to be comparable to chrome-plated brass in wear resistance. With the higher initial cost of chrome-plated brass, it would be more economical to use hardened stainless steel or stainless steel.

CONCLUSIONS

Based upon the information obtained in these experiments and upon inference, [6/] the following conclusions may be drawn:

1. Although diuron in the wettable powder form is cheaper than it is in the liquid suspension form, the wettable powder is more abrasive than the liquid suspension diuron.
2. Water alone, when pumped through nozzles, will produce nozzle wear.
3. The smaller the nozzle the quicker it will wear and need recalibrating.
4. The spray pattern of nozzles was not seriously affected by wear.
5. Stainless steel nozzles are more resistant to abrasive herbicides than brass nozzles and less resistant than chrome-plated brass nozzles.
6. Unless recalibrations are made daily to offset the wear of brass nozzles, an increased rate and subsequent cost of herbicide applied per acre can be expected.
7. Use of the more expensive stainless steel, chrome-plated brass, or hardened stainless steel nozzles may be justified over use of brass nozzles, depending upon the size of nozzle, the number of acres to be sprayed, and the concentration of the diuron mixture.

6/ See footnote 4 on page 1.